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Soil Sampler for Rocky Soils

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ABSTRACT.—Describes a portable hand-operated sampler and extractor for extracting undisturbed soil cores from rocky soils.

KEY WORDS: Forest soils, bulk density, soil sampling, root-soil-cores.

Relatively undisturbed soil samples are required for many forest studies. However, minimizing disturbance in soil samples is difficult when soils are rocky and contain large roots. The root systems of trees extend deeper in the soil than do most field crops, thus creating the need for deeper sampling. These hindrances to collecting intact soil cores on rocky, sloping sites and the need for deeper sampling create the need for specialized sampling devices. Numerous samplers have been developed, including hand-operated samplers, explosive-charged devices, and machine-driven, tractor-mounted samplers (Jurgensen *et al.* 1977, Hayden and Robbins 1975, Robertson *et al.* 1974, Schickedanz *et al.* 1973, McIntyre and Barrow 1972, Hayden and Heinemann 1968). Dug pits and power-driven soil samplers have been recommended for soils containing rocks and large roots (Hoover *et al.* 1954); however, neither method may be satisfactory if intact soil cores are desired.

Much of the forest in southern Missouri occupies land in the Missouri Ozarks. The soils there are rocky, derived from cherty residuum of weathered Ordovician and Cambrian dolomite limestones and shales. A complete replicate of the USDA Forest Service National Long-Term Soil Productivity Study (LTSP) (Powers *et al.* 1989) was established on these soils. The study protocols include the need for both disturbed and undisturbed soil samples to depths of 35 cm and deeper. Current samplers were not adequate to meet sampling criteria specified in the LTSP study plan for our site. We were unable to drive an impact-hammer-driven sampler, similar to the ones described by Jurgensen *et al.* (1977) and Tuttle *et al.* (1984), into the soil. Steep slopes (18-30%) and trees on the site prevented the use of machine-drawn tractor-mounted units; and explosive devices would not have produced undisturbed samples.

To meet the sampling criteria in the LTSP study, we developed a soil sampler that can extract intact cores from at least 35 cm in the soil profile (fig. 1). In this paper, we describe the sampler, the extractor, and other materials used to collect undisturbed soil samples from a study site in the Missouri Ozarks.

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Figure 1.—*Portable soil sampler being positioned by two-person crew to extract soil sample.*

METHODS AND MATERIALS

In developing the sampler, we concentrated our efforts first on inserting a soil core cylinder into the soil to the desired depth. We located a used motor-driven, portable, two-person, post hole digger to use as a driver. We removed the drive shaft at the gear box where the hole-digger assembly would normally be attached, connected the connecting shaft we developed (fig. 2), and attached the coring cylinder. The device was capable of driving a coring cylinder with a diamond cutting head into the soil, but the cutting head was destroyed during the first few trials. It appears that the random distribution of gravel and rock in the soil and their differing shapes and sizes prevented an even downward force from being applied. This caused the cutting to be rough and destroyed the cutting head on the cylinder.

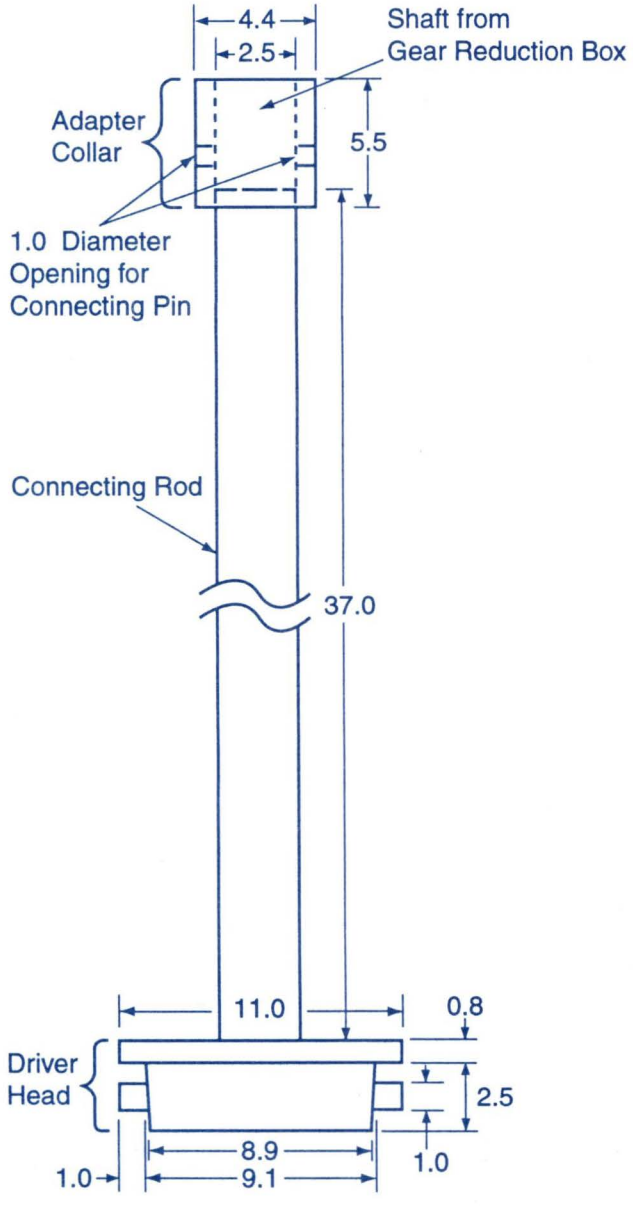

Figure 2.—*Connecting shaft for portable soil sampler. Measurements are in centimeters.*

After determining that the apparatus was capable of driving the coring cylinder into the soil, we turned our attention to the corer. Several materials were tried as coring cylinders and as cutting heads, including the coring cylinder without a diamond cutting head. We found that sections of steel pipe, 5 mm thick with an inside diameter of 9.5 cm, cut into lengths of 40 cm, were most satisfactory. The pipe thickness eliminated the need for a special cutting edge. Cutting four depressions 5 mm deep into the cutting edge of the cylinder at approximately equal distance apart allowed smooth cuts. Although the sampler produced undisturbed soil cores, the cylinder sustained substantial wear, especially on the cutting edge. The depressions usually wore off after extracting two to four samples.

The head of the coring cylinder consists of an 8-cm-long, 5-mm-thick steel sleeve, with a 9.2-cm inside diameter (fig. 3). A band of material approximately 2 mm thick and 4.2 cm long was removed from around the top of the sleeve on the inside to accommodate the connecting shaft. A band of material of similar thickness and 3.8 cm long was also removed from the outside of the sleeve at the bottom, thereby making the outside diameter of the sleeve the same as the inside diameter of the length of steel pipe (cylinder). The top of the cylinder was placed over the longer sleeve and spot welded to the outer sleeve. Excessive welding material was removed with a grinder. The coring cylinder was attached to the connecting shaft by matching the two openings that were cut into the top of the cylinder to the extensions on the bottom of the connecting shaft. When the length of a coring cylinder became less than 30 cm, the weld was heated, the old cylinder was removed from the sleeve, and a new cylinder fashioned from a length of steel pipe was added.

A soil core extractor was developed to remove soil cores from the coring cylinder (fig. 4). The core extractor consisted of a used car bumper jack attached (welded) to a metal frame. The bumper attachment was discarded. The frame provided stability and a cradle for the core

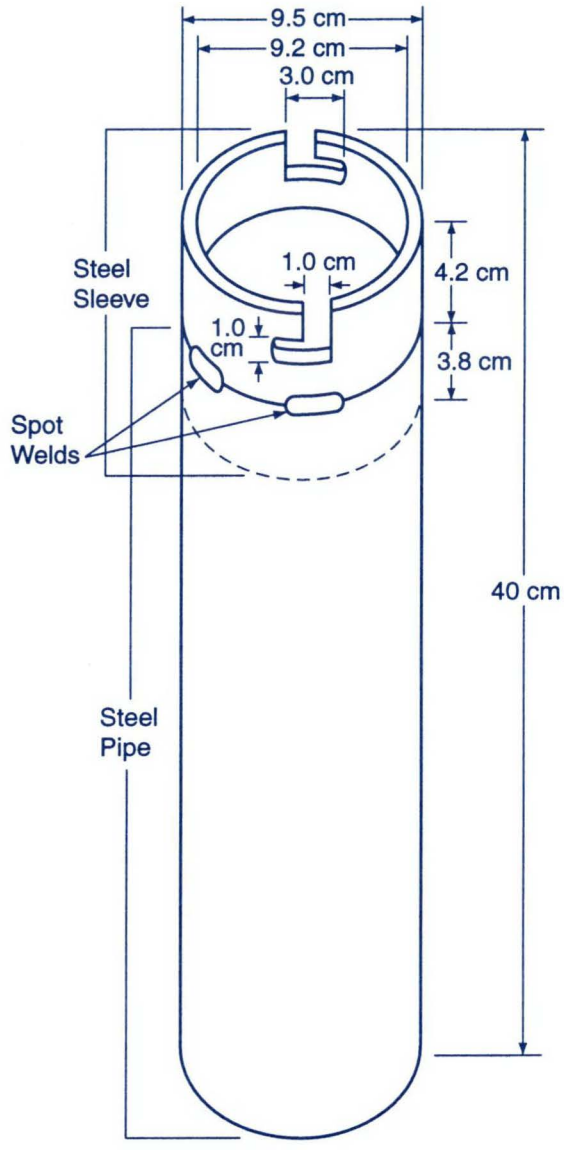

Figure 3.—*Coring cylinder consisting of a steel sleeve and replaceable steel pipe.*

Figure 4.—*Crew using core extractor to remove soil sample from coring cylinder.*

cylinder containing the sample and the sample container. Lengths of 38.0- X 10.2-cm-diameter PVC pipe sawed end to end lengthwise on one side were used as containers for the intact cores. The lengthwise cut allowed the pipe to spread for easy insertion of the soil core. Metal extensions on the cradle, similar to the ones on the connecting shaft for attaching the coring cylinder, served as anchors for attaching coring cylinder while the soil core was being forced out. A metal disk, 7.62 cm in diameter, was welded to the "forward-end" of the core extractor's shaft. After the coring cylinder was properly positioned in the core extractor, a PVC container was placed over the bottom end of the coring cylinder to receive the intact soil sample. Locking the "up and down" mechanism on the core extractor in the up position and moving the lever back and forth moved the shaft against the soil sample, forcing it into the container (fig. 5).

Figure 5.—*Soil sample being extracted into soil sample holder for transporting.*

SAMPLER OPERATION

Removing the sampled soil from the coring cylinder was made easier by a 9.0-cm steel disk. The 5-mm-thick disk was positioned on the ground at the spot where the sample was to be taken. Before starting the sampler, we positioned it with the cutting edge of the coring cylinder placed over the disk. The disk moved up into the cylinder as it was filled with soil. The shaft on the extractor pushed against this disk in the process of extracting the soil core. After the soil sample was extracted into the sample container, the container of soil was removed from the extractor, squeezed tightly so that the lengthwise sawed edges slid over each other, taped along the

sawed seam and at both ends with duct tape, and labeled (fig. 6). Sealing the tubes with tape reduced soil moisture loss and soil disturbance while transporting. When the length of the soil sample was less than the length of the sample container, placing several rocks or a handful of leaves in the end of the container before taping helped keep soil in place. The containers of soil were placed in 40.6 cm L X 40.6 cm W X 30.5 cm H plastic crates for transport to the laboratory.

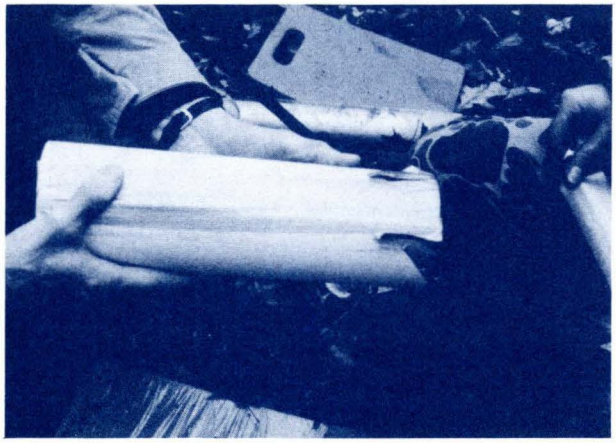

Figure 6.—*Soil sample in sample holder being secured with duct tape.*

We did not investigate the possibility that our method of obtaining undisturbed soil samples might compact the core. Tuttle *et al.* (1984) reported no increase in soil bulk density attributed to the coring method in a sandy loam soil with 2 to 5 percent rock fragments, but did report an increase for loamy sand with very few to no rock fragments. In addition to our sampling, the device we developed has been used to collect more than 300 samples without any measurable differences between core lengths and hole depths for the samples (M. David Hammer, personal communication).

We have found the soil sampler to be an effective tool in collecting undisturbed soil cores for determining bulk density and for investigations involving root and soil nutrient measurements up to 35 cm deep (fig. 7). A two-person crew can extract and prepare for transporting 8 to 10 cores per hour on sloping (18 to 30%) rocky soils.

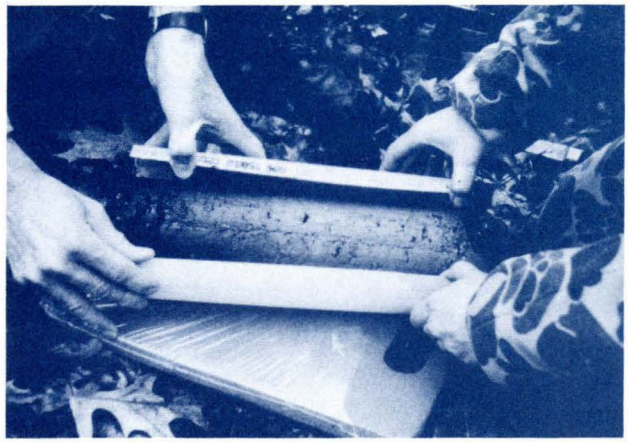

Figure 7.—*Sample holder being opened to examine soil sample for disturbance.*

Operating this sampler requires two people, but a third person would make the sampling operation easier, especially on sloping terrain. The extra person could help extract, tape, and label samples, and help transport the sampler components and soil cores.

The PVC containers and crates are durable and are available at hardware and dry goods stores. The components of the sampler are of sturdy metal construction. The post hole digger engine and mount can be purchased at a variety of vendors. The remaining components can be fabricated in most machine shops from readily accessible materials.

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